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# SUGGESTIONS FOR THE CONTROL OF INJURIOUS INSECTS AND PLANT DISEASES

BY

G. M. BENTLEY



AN EFFICIENT, INEXPENSIVE POWER SPRAYER

KNOXVILLE, TENNESSEE

# The Agricultural Experiment Station

OF THE UNIVERSITY OF TENNESSEE

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The Experiment Station building, containing the offices and laboratories, and the plant house, are located on the University campus, 15 minutes' walk from the Custom House in Knoxville. The experiment farm, the barns, stables, dairy buildings, etc., are located one mile west of the University on the Kingston Pike. The fruit farm is adjacent to the Industrial School, and is easily reached by the Lonsdale car line. Farmers are cordially invited to visit the buildings and experimental grounds.

Bulletins of this Station will be sent, upon application, free of charge, to any farmer in the State.

# SUGGESTIONS FOR THE CONTROL OF INJURIOUS INSECTS AND PLANT DISEASES

By G. M. Bentley

Many people believe that insects and fungi are controlled only by applications of chemical preparations, and give little attention to the prevention of attacks by cultivation, drainage, planting, and rotation, based upon a knowledge of the habits and life-histories of the pests. This impression has led the writer to give the suggestions below regarding preventive measures. This bulletin is a revision of Bulletin 106, which is out of print.

## PREVENTIVES

**In general**

While much may be accomplished in the control of insects and fungous diseases by the use of insecticides and fungicides, more attention should be given to the prevention of the introduction of crop pests by judicious legislation, to the selection of resistant plants, to the elimination of weeds and worthless plants which harbor pests or act as intermediary hosts and are often of the same family as those under cultivation, to judicious rotation of crops, and to better drainage, cultivation and fertilization.

**Cultural methods**

Cultural methods of overcoming attack and injury by pests are based upon a knowledge of their habits and life-histories. Simple rotations, the use of trap plants, fall plowing, early planting, and many other average operations of the farm, if done with an intelligent knowledge of the habits and development of the pests to be controlled, will often of themselves prove efficient.

**Rotation**

The succession of the same or similar crops on the same land has proved disastrous in more ways than by the reduction of soil fertility. Its encouragement of the increase of insects and fungi has become notorious. The corn-root worm, boll worm (or corn-ear

worm), Hessian fly, and many other pests are more or less affected by crop rotation, and their control by this method should be carefully studied.

In sections affected with contagious diseases of live stock, pasture rotation is essential. In the control of stomach and intestinal worms in sheep, hogs and cattle, intelligent rotation covering definite periods, based upon longevity and life-histories of the pests, is now recognized as the most available and economical plan.

The fever cattle tick may be permanently eradicated by positive rotation. It has been found that if cattle and horses are removed from a pasture during the summer months, it becomes free from ticks. During the winter if infested cattle are run upon a cornfield or other cultivated field upon which no animals have been during the summer all the ticks will drop off, after which the animals may be placed upon the pasture that was freed of ticks during the previous summer. The Tennessee Experiment Station has prepared a bulletin upon the eradication of the tick by pasture rotation methods, which may be had on application.

**Beneficial insects**

While it may seem anomalous, probably the greatest factors in the control of insects are other insects and fungous diseases which are parasitic within or upon them. Such are truly friends of the producer, but they cannot be brought thoroughly under his control until insect life is better understood. Unable to identify these friends or to understand their operations, man too often treats them as enemies or minimizes their mission.

**Birds**

Birds should be recognized as factors in insect control. It is not uncommon to find large numbers of birds doing effective work in controlling insect outbreaks.

## NOTES OF PRACTICAL INTEREST TO FARMERS AND FRUIT GROWERS ON THE SUBJECT OF SPRAYING

All chemicals used in spraying should be kept correctly labeled and out of reach of children.

Never spray when the trees are in bloom. Such practice will injure developing fruit and kill bees, which are necessary for fertilization. Spray before the buds open and just after the blooms fall. The strong lime-sulphur solution is most effective in February and March.

In all the formulas which require quicklime, the best stone lime, freshly burned, should be used. Air-slaked lime will not answer.

When hydrocyanic acid gas is used, fully fifteen minutes should be allowed for ventilating the enclosure after the fumigation is over.

This gas being a *deadly poison*, strict precautions against breathing it should be taken.

Bordeaux mixture should be applied several times; once before the buds break, once after the blooms fall, and again after a lapse of ten days or two weeks. A fourth application may be made a week later. With some fungous diseases Bordeaux may be profitably used every ten days or two weeks. If the lime-sulphur wash has been used the first application of the Bordeaux may be omitted.

*Information about insects and insect pests and fungous diseases will be gladly furnished if specimens of insects and affected plants are sent to us. Place the specimens in a box, wrap neatly, and put your name and address on the package. In an accompanying letter tell us all you have noticed about the insect or disease—its first appearance, rapidity of increase, extent of destruction, etc.*

Never put the strong lime-sulphur solution in a copper sprayer. The chemical action between the copper and the solution is rapid, and does great injury to the sprayer. For the lime-sulphur solution a galvanized iron or wooden receptacle should be used.

In spraying, great care should be taken to cover all parts of the tree, shrub or plant. If a heavy rain immediately follows your application of a spray, the work should be done over. Do not spray when the foliage is wet.

Before spraying, it is best to prune the trees in order to economize in the surface to be covered by the spray; also to rid the trees of their worst-affected limbs. Burn the wood removed. Prune out the scale-affected branches, the dead wood, and the undesirable water sprouts. In the peach, new wood should make up the major part of the tree. An ideal time to spray is a quiet, bright day when the air is dry and cool.

Study spray formulas, and the different makes of spray pumps and nozzles, that you may select the best for your conditions.

**Insecticides and fungicides**

Insecticides are agencies which kill insects. Fungicides are agencies which destroy fungous diseases. When insects and fungous diseases prevail upon the same plants insecticides and fungicides may be combined and the two results gained from one application. Variable results have been obtained from the use of insecticides and fungicides, due largely to climatic conditions and to the quality, age and preparation of the ingredients used and the combinations made. A knowledge of the pest being treated and the nature of the plant infested is important.

For remedial treatment, insects are divided, according to their manner of feeding, into biting and sucking groups. Hence, in the economic application of insecticides a knowledge of the mouth parts

of insects is essential. To obtain this, one has only to notice carefully the damage being done or study the insect and observe whether its mouth is provided with jaws for biting (chewing) or a beak for sucking. Until a distinct familiarity with insect anatomy and general classification is procured it may be better to send specimens to the Experiment Station for identification and remedial suggestion. Specimens should be accompanied by pieces of plants upon which the insects feed, and if possible samples of the damage done.

## INSECTICIDES FOR BITING INSECTS

(Potato beetle, flea beetle, codling moth, currant worm, etc.)

### 1. Arsenate of Lead (Liquid)

Powdered arsenate of lead..1 to 3 pounds or 1 tablespoonful
Water.....50 gallons or 1 gallon

or

Paste arsenate of lead.....2 to 6 pounds or 2 tablespoonfuls
Water.....50 gallons or 1 gallon

### 2. Arsenate of Lead (Dust)

Powdered arsenate of lead..... 1 pound
Flour, air-slaked lime, road dust or ashes.....10 pounds

To make a spray dissolve the dry or paste form of arsenate of lead in a small quantity of water, then dilute to make the desired quantity.

## INSECTICIDES FOR SUCKING INSECTS

(Plant lice, scale, squash bug, etc.)

### 3. Kerosene Emulsion

Kerosene (coal oil) .....2 gallons
Soap .....½ pound
Water (soft) ..... 1 gallon

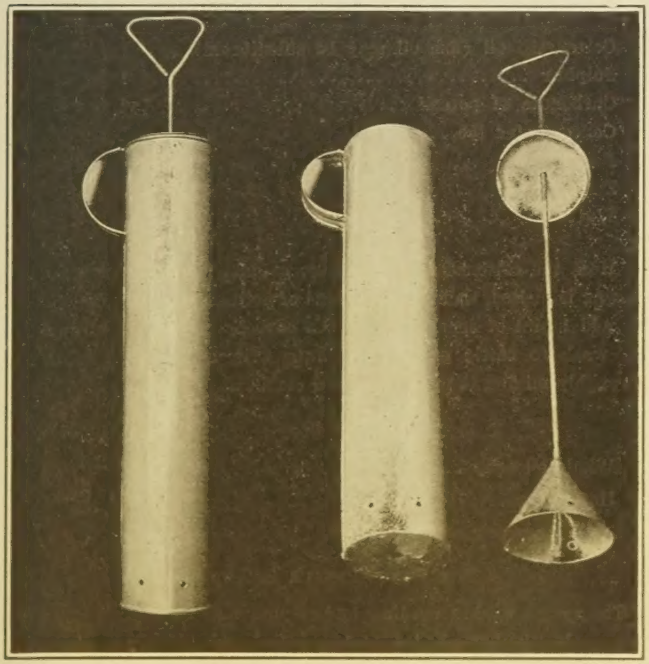
Dissolve the soap in water by boiling, remove from the fire, add kerosene, mix vigorously until all forms a creamy mass and emulsion. Dilute according to the per cent wanted.

For 10 per cent oil emulsion add 17 gallons of water
For 15 per cent oil emulsion add 10½ gallons of water
For 20 per cent oil emulsion add 7 gallons of water
For 25 per cent oil emulsion add 5 gallons of water
For 30 per cent oil emulsion add 4 gallons of water
For 40 per cent oil emulsion add 2 gallons of water
For 50 per cent oil emulsion add 1 gallon of water

How to make an oil emulsion

In the making of an emulsion it is essential that the oil when added to the water be thoroughly agitated in order that a thorough mixing of the ingredients may be obtained. This may be accomplished by turning the nozzle of the force pump into the mixture and forcing the solution through. The heat, however, is injurious to the valves of the pump. A jet of steam, if handy, could be used with good results. A simple device for making a perfect emulsion is one originated by Prof. H. A. Morgan, mentioned in Bulletin No. 48 (second series) of the Louisiana Agricultural Experiment Station, Baton Rouge, La.

It consists of a tin cylindrical vessel, 18 inches long and 4 inches in diameter, and a plunger, or piston, 22½ inches long, as shown on



A B C

AN EMULSIFIER

page 115 (A and B). About 1 inch from the lower end of the cylinder is a row of seven holes each ¼ inch in diameter. In the center of the bottom of the cylinder is a single opening ½ inch in diameter. The plunger consists of a ¼-inch iron rod with tin cone 3½ inches high and of a circumference that will permit it to fit nicely within the cylinder, as shown on page 115 (C). This is firmly soldered on one end of the rod and a handle is fitted on the other. A row of five holes, each ¼ inch in diameter, is made ½ inch from the base of the cone. In the base is an opening ½ inch in diameter. The openings at the base of the cone may be increased in number and lessened in diameter. This hastens the operation of emulsifying, but increases the labor. The above-described implement can be made by any tinsmith, and is inexpensive.

4. Treatment for Ticks, Horn Flies, Stable Flies, Etc.

| | |
|---|---|
| Cottonseed oil (fish oil may be substituted) | 1 gallon |
| Sulphur | 1 pound |
| Carbonate of potash | 1 pound |
| Concentrated lye | 3 ounces |
| Beeswax | ½ pound |
| Zenoleum | 1 pint |
| Water | 3 gallons |

Heat the cottonseed oil, sulphur, potash, and beeswax until the beeswax is melted, then add 3 gallons of cottonseed oil or fish oil. To this add 1 pint of zenoleum or crude carbolic acid. Before applying this wash to cattle or horses, dilute with equal parts of water, thoroughly mixing it to form a good emulsion.

5. Whale Oil Soap Solution

| | |
|---|---|
| Whale oil soap | ¼ pound |
| Hot water | 1 gallon |

Use for summer spray.

The Lime-Sulphur Solutions

The sprays made from lime and sulphur may be divided into three classes, viz., the home-boiled, factory-boiled and self-boiled. The first two act both as fungicides and insecticides; the last only as a fungicide. All the lime-sulphur solutions have efficiency and cheapness, which commend them highly.

### 6. Home-Boiled Lime-Sulphur Solution

Home-boiled lime-sulphur may be made after many different formulas. The one which we have used with best success is made from

| | |
|---|---|
| Stone lime (burnt lime) | 21 pounds |
| Flour of sulphur | 18 pounds |
| Water | 50 gallons |

Into the boiler, kettle, or tray (a barrel or tank if steam is to be used) place 5 or 6 gallons of water; to this add the sulphur, which has been passed through a flour sieve; then the lime, a small quantity at a time. Fire should now be started under the boiler. After all the lime has been added and the slaking is finished, add water to keep to a good boiling consistency, and boil vigorously from 40 to 60 minutes. The solution is now ready to be thinned and strained carefully into the spray tank or barrel; sufficient water being added to make 50 gallons of spray.

This spray is for winter, late fall, or early spring use. Never use while leaves or buds are opening. Never put this solution into a copper tank or sprayer, for its action upon copper is rapid and will soon ruin a receptacle of this metal.

This winter spray is for San Jose scale and leaf-curl.

### 7. Factory-Boiled Lime-Sulphur Solution

A very similar solution can be obtained in concentrated form from factories, and is then known as the factory-boiled lime-sulphur solution. This is usually diluted with from 7 to 9 parts of water to make the winter spray. There are many reliable grades which are as efficient as the home-boiled solution. If good lime cannot be obtained and the proper care given in making the mixture the factory-boiled solution should be used. The commercial product, at its present price, and of the quality now being furnished, is to be recommended.

### 8. Self-Boiled Lime-Sulphur Solution

The experiments with the self-boiled lime-sulphur solution for several years in different states have given results which highly commend this spray for the troubles which have heretofore been met with difficulty. Credit is due Mr. W. M. Scott, formerly Pathologist of the Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C., for his preliminary experiments in 1907 and 1908. The following formula, which has given best results, is from Bulletin 174 of that Bureau:

| | |
|---|---|
| Flour of sulphur | 8 pounds |
| Fresh lime (burnt) | 8 pounds |
| Water | 50 gallons |

Best results can be obtained by making a larger quantity, say four times this amount, as follows: To 8 or 10 gallons of water in a barrel add 32 pounds of fresh stone lime (the quicker-acting the better); when the slaking begins add 32 pounds of fine sulphur which has been run through a sieve to break up all lumps. As the lime continues to slake, water may be added to keep it from drying. The mixture should be constantly stirred until the slaking is over, when more water is added to stop the cooking. Strain and dilute to make 200 gallons of spray. Only a small amount of soluble sulphur should be present; the desired solution is a mechanical mixture of lime and sulphur. In straining the spray the coarse parts of the lime are to be taken out, but the sulphur worked through the sieve.

### HOW AND WHEN TO USE THIS SPRAY

The self-boiled lime-sulphur solution should be applied in the form of a fine spray by a pump equipped with a good agitator. The time for applying will be governed by the disease to be treated. The number of applications may be one, two, three or four, according to conditions and the objects sought.

In place of the self-boiled lime-sulphur solution made at home, the commercial concentrated solution may be diluted for summer use. With peach this should be used experimentally. With apple the following reduction gives good results:

| Hydrometer reading of the concentrated lime-sulphur solution<br>Degrees Baume | Water to add to one gallon of the commercial concentrated lime-sulphur solution<br>Gallons |
|---|---|
| 35 | 45 |
| 34 | 43½ |
| 33 | 41¼ |
| 32 | 40 |
| 31 | 37½ |
| 30 | 36¼ |
| 29 | 34¼ |
| 28 | 32¾ |
| 27 | 31 |
| 26 | 29½ |
| 25 | 27¼ |

The lime-sulphur wash, from the standpoint of cheapness, accessibility, and efficiency, is the best spray known for the San Jose scale.

The time for applying the lime-sulphur wash is while the trees are dormant, as in the late fall, winter, or early spring. Prune the trees before spraying, and do thorough spraying. If all parts of the trees cannot be covered at the first spraying repeat the process soon.

9. Tobacco Solution (Homemade)

Tobacco (waste of stems) ..... 1 pound
Water ..... 3 gallons

Steep in a covered vessel for 3 hours; strain, and use as a spray. For delicate foliage, this concentrated solution may be reduced with equal parts of water.

The soap-solution formula given below may be added.

10. Tobacco Solution (Factory-made)

There are today on the market several preparations of concentrated tobacco solutions. They are sold under various trade names, and contain 10, 20, 30, and 40 per cent of nicotine, by weight. They are very convenient to use. The amount of dilution is indicated upon the container.

11. Tobacco Dust

Tobacco dust, snuff, or warehouse sweeping can be used with partial success against the root aphis.

12. Soap Solution

Laundry soap ..... 1 pound (2 bars)
Water ..... 15 gallons

Dissolve the soap in hot water and apply when warm.

13. Starvation Method for Killing Cutworms

Late summer cultivation, followed by shallow cultivation throughout the fall, winter and early spring months, will in a large measure starve out the cutworm. All growths should be kept from the soil during the late summer, fall, winter, and early spring. The few worms that remain will be readily attracted by poison bait.

14. Bait for Cutworms

Bran or middlings ..... 40 pounds
Paris green ..... 1 to 2 pounds

Add enough molasses to sweeten well; mix with water to make a thick mash. Spread around on the ground late in the evening. Keep fowls from this.

## FOR FUMIGATING

15. Hydrocyanic Acid Gas (Strong)

For fumigating apple and pear stock, plums and peaches, one year old, and for all other hardy deciduous trees, one year old or more; also for the control of household pests.

For each 100 cubic feet of space in the fumigating house or box, use potassium or sodium cyanide and sulphuric acid, as follows:

Potassium cyanide (guaranteed 98 per cent pure) .. 1 ounce
Sulphuric acid (sp. g. 1.83) ..... 2 ounces
Water ..... 4 ounces

or

| | | |
|---|---|---|
| Sodium cyanide (96-98) | 1 | ounce |
| Sulphuric acid | 1½ | ounces |
| Water | 2 | ounces |

Stock to be fumigated 40 minutes.

### 16. Hydrocyanic Acid Gas (Weak)

For fumigating June-budded stock and for roses, buds, and scions, use the following charge:

| | | |
|---|---|---|
| Potassium cyanide (guaranteed 98 per cent pure) | ⅔ | ounce |
| Sulphuric acid (sp. g. 1.83) | 1½ | ounces |
| Water | 3 | ounces |

Stock to be fumigated 40 minutes.

*Caution.*—Hydrocyanic acid gas is lighter than air, highly penetrating, and a *deadly poison*. The enclosure in which this gas is used should be perfectly air-tight. Care should be taken to get the right chemicals for this fumigating, the cyanide to be fused 98 per cent, the sulphuric acid to be the best commercial, specific gravity 1.83. For more detailed information upon fumigation, see Bulletin No. 2 of the Tennessee State Board of Entomology, on The Fumigation of Nursery Stock.

### 17. Carbon Bisulphide

For fumigating grain bins and other enclosures.

1½ tablespoonfuls to 100 lbs. grain.

5 lbs. to 100 bu. grain.

5 to 8 lbs. to 1000 cubic feet.

Leave in tightly closed bin for 24 hours. The bisulphide may be thrown upon the grain, or it may be put into shallow dishes and set upon the grain. The gas is much heavier than air and sinks down through the grain, killing any insects that may be there. The temperature should be 65 degrees or higher. A trade name for carbon bisulphide is "Fuma."

*Caution.*—Carbon bisulphide is highly inflammable. The enclosure containing this gas should not be approached with a lighted lantern, match, pipe, or cigar. When fumigation is over the bin should be thoroughly ventilated.

### 18. Carbon Tetrachloride

2 pounds to each 100 cubic feet.

This fumigant is non-explosive and may be used in place of carbon bisulphide, where there is possible danger of fire. It is slower in its action than carbon bisulphide.

### 19. Sulphur

Burn 6 ounces of sulphur in a space of 1,000 cubic feet. Keep closed for at least 12 hours.

### 20. Nikoteen

Nikoteen ..... ..... 1/7 ounce
Water ..... ..... 5 ounces

Place this upon a hot steam pipe and let it vaporize at night. The amount given above is sufficient for a space of 1,000 cubic feet.

### 21. Para-Dichlorobenzine

A new fumigant known as Para-dichlorobenzine does effective work in killing insects. Its action is slower than hydrocyanic acid gas, but it is very effective, and has the advantage of being neither inflammable nor poisonous to inhale.

### 22. Heat

To raise the temperature of a room or building to 120°F. and maintain this temperature from 8 to 24 hours, will kill insects of stored products, grain and flour, and also household insects.

## FUNGICIDES

### 23. Self-Boiled Lime-Sulphur Solution

Stone lime (burnt lime) ..... 8 pounds
Sulphur (flour) ..... 8 pounds
Water ..... ..... 50 gallons

### 24. Regular Bordeaux Mixture

Copper sulphate (bluestone) ..... 5 pounds
Quicklime (burnt lime) ..... 5 pounds
Water ..... ..... 50 gallons

Dissolve the copper sulphate by suspending it in a bran bag or gunny sack in a wooden vessel containing 4 or 5 gallons of water. Slake good burnt lime in another vessel. When ready to use the Bordeaux mixture, add each of the above-mentioned solutions to two separate barrels, each diluted to make 25 gallons. These two solutions may now be added by pouring one into the other and thoroughly mixing. The result is 50 gallons of the Bordeaux mixture ready for use. This solution may be used on foliage not especially sensitive to copper.

### 25. Strong Bordeaux Mixture

Copper sulphate (bluestone) ..... 6 pounds
Quicklime (burnt lime) ..... 4 pounds
Water ..... ..... 50 gallons

Separated, the sulphate and lime may be kept for some time, but when mixed the solution should be used at once.

### 26. Weak Bordeaux Mixture

Copper sulphate (bluestone) ..... 2 pounds
Quicklime (burnt lime) ..... 2½ pounds
Water ..... ..... 50 gallons

Make according to directions under "24."

### 27. Ammoniacal Copper Carbonate Solution

Copper carbonate ..... 6 ounces
Ammonia ..... ..... 3 pints
Water ..... ..... 40 to 50 gallons

Dissolve the copper carbonate in the ammonia. The solution may

be kept in a jar or bottle tightly corked. When ready for use dilute with water.

28. Copper Sulphate Solution

Copper sulphate (bluestone) ..... 4 pounds
Water to make .....50 gallons

For use before the buds open, the above solution is fully as effectual as Bordeaux mixture, and is easier to prepare and apply. The weaker solution should be used upon the peach, although no injury would be done upon any kind of fruit tree, while in a dormant condition, if the stronger solution were used. *The stronger solution should not be applied to any plant after the buds have opened.*

29. Potassium Sulphide Solution (Liver of Sulphur)

Potassium sulphide .....1 ounce
Hot water .....2 to 3 gallons

Use as soon as it is cool.

30. Formalin Solution (For Oat and Wheat Smut)

Formalin (40% formaldehyde gas) .....1 pint
Water .....50 gallons

Soak the grain in this mixture for an hour and a half; spread out to become partly dry before sowing.

Grain may be piled upon a smooth floor and sprinkled with the solution, and shoveled over until the whole pile has been dampened. If this method be adopted, extreme care is necessary to insure the thorough dampening of every grain.

31. Formalin Solution (For Potato Scab)

Formalin .....16 ounces
Water .....30 gallons

Before cutting potatoes for planting, place them in a sack and soak them for two hours in the above mixture.

32. Corrosive Sublimate Solution (For Potato Scab)

Corrosive sublimate ..... 2 ounces
Water .....15 gallons

Dissolve the corrosive sublimate in 2 gallons of hot water and dilute to make 15 gallons. Soak potatoes in solution for an hour and a half before cutting them.

33. Corrosive Sublimate Solution (For Cabbage Seed)

Corrosive sublimate ..... 1 part
Water .....1000 parts

Soak seed in this solution for 15 minutes. Black rot may be introduced on cabbage seed. It is advisable to soak seed as directed under "32."

## SPRAYING TO KILL WEEDS

### In Lawns, Parks, Pastures and Hay and Grain Crops

The herbicides mentioned below can be used to destroy such weeds as mustard, dandelion, oxeye daisy, white-top, thistle, carrot, parsnip, elder, poison-ivy, ragweed, and all broad-leaved weeds. These sprays will leave narrow-leaved crops such as blue grass, timothy, red-top, and other grasses, including the growing cereal grains—wheat, oats, rye, etc., without injury if applied in proper strength and at the proper time.

The time of applying the sprays has to be adjusted to the condition of the crop and the relative development of the weeds. The first spraying should be made not later than the beginning of the bloom, and repeated applications should be made as new leaves are developed, provided the condition of the host crop will permit it. In grain fields, the best results with a single spraying will be obtained on most weeds by applying the spray just as the crop is ready to occupy the land.

Timothy and other grass meadows should be sprayed just before the grass begins heading out.

There are several solutions which may be used, but in general common salt and iron sulphate solutions are found most satisfactory. They are effective in killing the more common weeds and are not dangerous to stock in pastures in which they may be used.

### HERBICIDES

#### 34. Common Salt Solution

Common salt .....150 pounds
Water ..... 50 gallons

Should be applied at the rate of 50 to 75 gallons per acre, sprayed. Useful for killing Canada thistle, dandelion, poison-ivy, yarrow, horse nettle, etc.

#### 35. Iron Sulphate Solution

Iron sulphate (copperas) .....100 pounds
Water ..... 50 gallons

Should be applied at the rate of 50 to 75 gallons per acre. Good to kill mustard, ragweed, white-top, yarrow, and other broad-leaved weeds in a field of growing grain or timothy.